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DEGENERATION PHENOMENA IN THE LARVÆ OF GONIONEMA.

HENRY FARNHAM PERKINS.

Every student of invertebrate embryology has experienced the difficulty of rearing eggs and larvæ of marine animals with a view to determining the stages in the life-history of the species. One of the chief contingencies to be encountered is that which arises from the necessity of supplying an artificial environment which approaches closely enough to the natural conditions to permit the creatures to live and thrive in captivity, and to develop normally. In the effort to secure these favorable conditions many failures are to be expected, and it frequently happens that remarkable monstrosities are produced by some untoward condition which can frequently be only guessed at. Interesting and significant tendencies are sometimes to be traced in these abnormal forms, and light is thrown upon the normal constitution of the tissues and their power of assuming a variety of forms.

The transforming and regenerative power which is displayed by cœlenterate tissues has been adequately demonstrated by investigators in various orders. Among the hydroids, several instances have been recorded in which the soft parts of the colonies exhibit amœbiform activity. In *Hydra*, when live specimens are mounted in water under a cover-glass, so that the tentacles are in contact with the glass, their tips are frequently seen to become spread out in a smear against the glass, and flowing movement is observable in the protoplasmic tissue-layers. It may be added that the same activity occurs in the tips of the tentacles in the *Hydra*-like polyps of *Gonionema*, which furnish the data for the present paper.

In *Plumularia cristata* the soft internal substance of the colony, the sarcode, flows out of the vase-like nematophores which are borne upon the ramuli of the zooids, and after being protruded for a short distance send out long filamentous pseudopodia; these frequently branch and anastomose, like the pseudopodia of the amœba. The processes are afterwards withdrawn again into

the nematophores. An account of this process was first given by Allman.¹

In the germ-plasm and ovarian eggs of certain members of the Hydrozoa, *Cunina* for example, amœbiform activities commonly occur. Metschnikoff² has described and figured many of these.

It will be remarked that these instances of amœbiform activities are all limited to portions of the individuals or to the earliest stages of unfertilized eggs. Dr. Loeb³ found in *Campanularia* that when parts of a colony were brought in contact with a solid object such as the bottom of a dish the hydranths in that part degenerated and the zooids were changed into soft flowing protoplasm. The entire individual was involved in this change. The epiderm of the hydranths affected was left quite empty of sarcode, this being used in formation of stolons at other points of the colony.

The condition in *Gonionema*, also is one of complete modification. The animal undergoes a decided change, losing its characteristic shape and appearance, and becoming transformed into a simple multinucleate plasmodium which sometimes exhibits amœboid movements.

The simplest case of this manifestation of the amœba-like character of the tissues appears in the tendency to fusion, seen in the young polyps of *Gonionema*. This takes place in the hydra-like larvæ which develop from the free-swimming planulæ; these latter have a way of settling down in clusters on the bottom of the vessel in which they were reared, and it is a common thing to see two or three of these larvæ quite fused together at the base, so that they appear to be double- or triple-headed monsters. While such larvæ frequently live for some time, I have never happened to see any in an advanced stage of growth; it is possible that the condition is degenerative, and that it is the result of defective oxidation.

¹ Allman, J. G., 1884., "Amœboid Protoplasm in Hydroids," *Ann. and Mag. Nat. Hist.*, 3 13.

² Metschnikoff, E., 1874, "Embryologische Studien," p. 110.
amœboid cells.

³ Loeb, Jacques, "On the Transformation and Regeneration of Organs." *Am. Jour. Physiology*, June, 1900.

A degenerate condition which is by far more striking and significant was observed in the case of individual polyps, which underwent fundamental changes of a remarkable character. The polyps in which these phenomena appeared were reared in the laboratory from eggs laid in August, 1901, at Woods Holl. Several lots of larvæ were reared in aquarium jars, some living for several months, others dying and quickly vanishing after a few weeks. Only one jar of larvæ exhibited the peculiar forms which are described in this paper. In all the jars, as nearly as possible, the natural conditions of the larvæ were imitated by keeping fresh algæ, ulva, diatoms, etc., in the water with the creatures. Some of the jars of polyps were left at Woods Holl for three months, and then forwarded to the zoological laboratory at Baltimore. These were found to contain healthy larvæ, which remained alive until February. But one of the jars, instead of remaining at Woods Holl for the balance of the summer, was taken directly to the laboratory, and the contents were frequently examined. About the first of October, the amœba-like forms were first seen. For some time no attention was paid to them, as they were simply taken for amœbæ which had been introduced with the sea water. But it was soon seen that the number of healthy polyps was rapidly diminishing, while the supposed amœbæ were becoming surprisingly numerous. More careful attention was then paid to the creatures, and it was discovered that the polyps were undergoing remarkable changes. Single individuals were noted from time to time, and observed to contract, first losing the *Hydra*-like aspect, the tentacles being completely retracted. The upright body of the polyp then settled down upon the glass, and all semblance of its natural shape was completely lost. Moreover, the differentiation between ectoderm and endoderm could no longer be discerned, except dimly in a few instances (*v*, Fig. 4). The cell-walls lost their distinctness and soon disappeared. In this remarkable way the originally vigorous hydra, standing upright with mouth gaping and tentacles widely extended, became quickly degenerated into a shapeless mass of substance without organs, only sluggishly motile, without discernible cell-boundaries or tissue layers, in short, an organism which was hardly more than a plasmodium.

In this condition the tissue of the creature was yellowish and translucent, with many inclusions of various sizes and shapes. The nuclei of the polyp were permanently visible, scattered unevenly through the substance. Vacuoles of varying size occurred in most cases, and a large number of foreign objects, such as bits of diatoms and disintegrating vegetable matter, particles of sand, etc., lay in the protoplasmic matrix.

This plasmodium showed most remarkable ability to move and change its form. From a regular mass of protoplasmic tissue long pseudopodia-like processes were seen to push out into the water or along the bottom. The creature had the power of flowing about on the bottom like an amoeba, and its changes

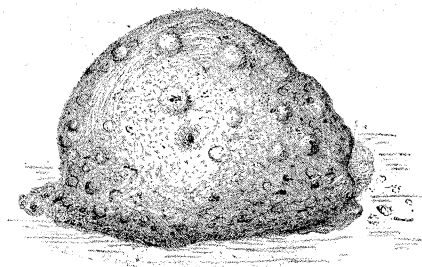


FIG. 1.

of form were sufficiently rapid to be readily noticeable. No definite type of form could be discovered, the changes being apparently endless in diversity. Several figures are given to show some of the forms which appeared in the course of my observations; these are merely typical, and do not represent a tithe of the peculiar appearances which came to my notice. All the shapes shown in the figures were such as single individuals were frequently seen to go through within a couple of hours' time.

Starting, perhaps, as a spheroidal mass adhering to the bottom by a broad, sole-like surface (Fig. 1), in which condition the creature may have been resting motionless for some time, the form was suddenly seen to show signs of life, and to elongate vertically, so as to send upward into the water a columnar process (Fig. 2). This grew rapidly more slender at the base while the free end enlarged into an irregular bolt (Fig. 3). Usually the

surface of the larvæ was seen to be covered with a number of thorn-like points, which were evidently the ectodermal cnidocils of the polyp (Fig. 1). There was no sign of the nematocysts, these

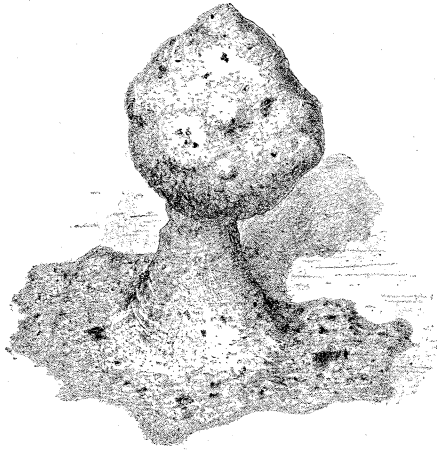


FIG. 2.

having disappeared early in the degeneration of the tissues. The permanence of the cnidocils is an interesting point in the degen-

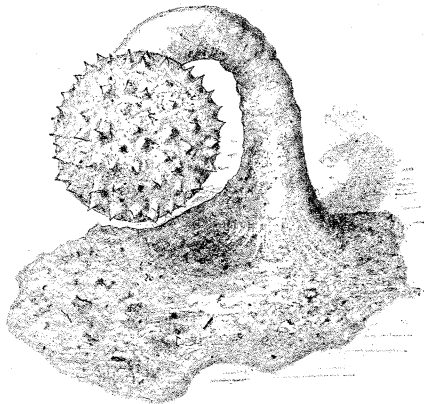


FIG. 3.

erative changes through which these larvæ were seen to pass. It gives a suggestion of the degree to which the tissue is stiffened and specialized to form these trigger-organs. From time to time

the outlines of the degenerated polyps, as seen in profile against the light, appeared smooth and devoid of cnidocils (Figs. 3 and 5.) But these same individuals soon changed their position in such a way as to display the full battery of trigger-organs, showing that the reason for the temporary disappearance was the flowing of the soft tissues, which caused the cnidocils to be engulfed in the substance, from which they were afterwards pushed outwards again to the surface. In the ball at the extremity of the columnar prolongation shown in Fig. 3 the cnidocils had temporarily disappeared, but with the subsequent changes of this individual they soon became visible again and remained so for a long time. The rod of tissue connecting this ball with the basal portion of the polyp became longer and more slender, and the mass at the tip assumed a more nearly spherical contour, as in Fig. 4. Following this appearance a change

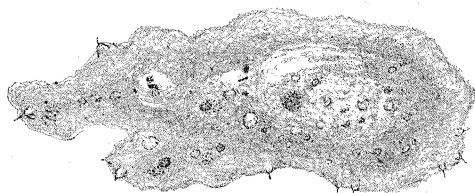


FIG. 4.

took place which was frequently manifested by the degenerating creatures and which ultimately brought about their disintegration. The ball at the tip of the rod-like process became constricted off and fell to the ground, there to undergo the same series of changes which characterized the previous history of the complete individual. The basal portion of the polyp, with the neck of tissue projecting from one part, became retracted into a more regular mass, and went on with its flowing movements and protrusion of pseudopodium-like processes. At first it was closely applied to the glass, and flattened at the edges (Fig. 5). It soon changed into the form shown in Fig. 6, which was the most common of all, and which was at first mistaken for an *amœba*. As the creatures moved slowly along the bottom, any minute particles of matter, organic or inorganic, which came in their path were engulfed by the protoplasm, and remained

there until ejected by the subsequent movement of the animal. It was not possible to determine whether these particles furnished any nutriment, but the long-continued activity of the degenerated polyps seemed to indicate their ability to absorb some food.

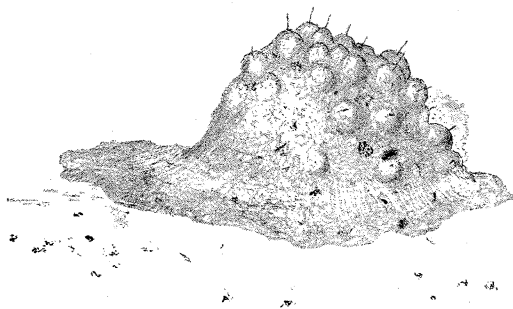


FIG. 5.

As the plasmodium crept along over the bottom it left in its wake a trail of particles which it had egested or which had become detached from the substance of the protoplasm itself.

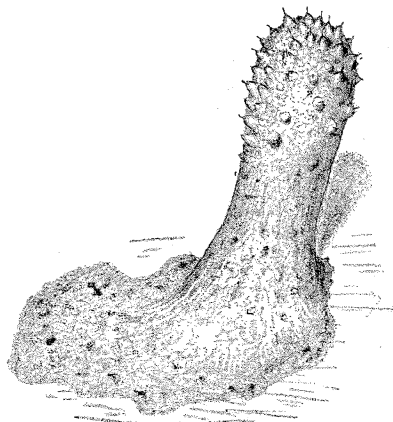


FIG. 6.

A form which was noticeable both for its remarkable appearance and its frequent occurrence is represented by Fig. 7. This was derived, in a comparatively short time, from such a form as that of Fig. 6, a long filamentous process being sent upwards into the water, free from the bottom. Along this process the

substance of the main mass flowed out gradually until it had accumulated as a spherical knob at its extremity. On the surface of this knob the cnidocils protruded in all directions. A second filamentous rod of tissue was projected from another portion of the mass, and a similar flowing movement of the substance resulted in another knob. This waving object then proceeded

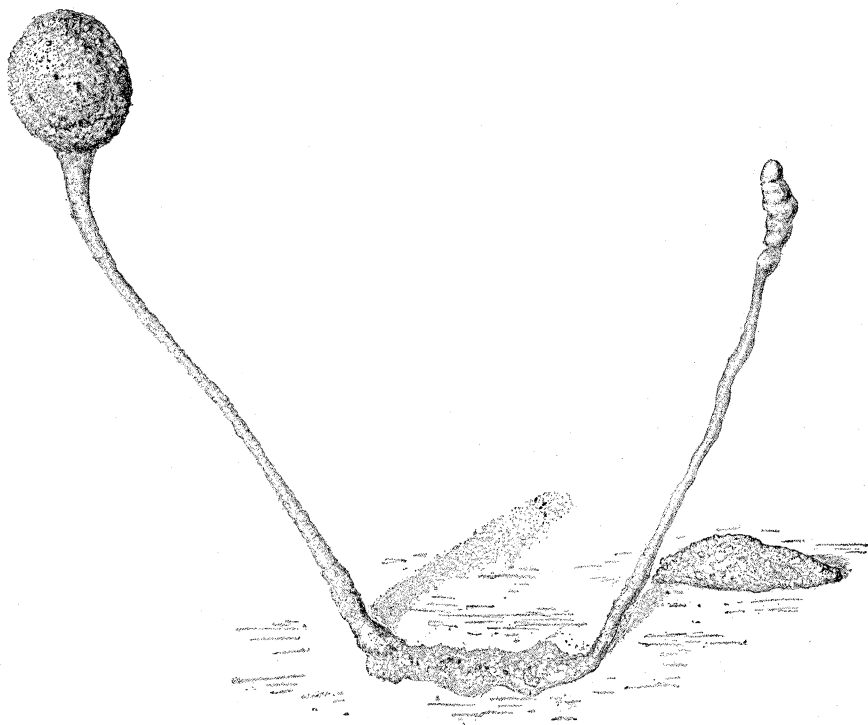


FIG. 7.

to crawl slowly over the bottom, the basal portion only exhibiting activity, and that the simplest. This form was frequently present in the dishes, as many as half a dozen specimens, more or less like Fig. 7, sometimes occurring within an area of not more than four square millimeters. By the constriction of the connecting rod at a point near the ball at its extremity, this latter mass was detached from the rest of the object, and settling down on the bottom began to move about in the characteristic way. The remaining stock of protoplasm, seen on the right in the

figure, shortened and shrivelled (Fig. 7). This form arises without the slightest traceable connection with the polyp-form, and its appearance seems entirely fortuitous. It is hard to see why it should be so common.

The plasmodium-like larvæ remained alive for nearly two months, showing the various forms and movements described. The repeated fission of the individuals resulted in such diminution of the size of the pieces which came from the original individuals that after a time it was impossible to distinguish the bits of living matter from the other particles lying about on the bottom. But during the entire time in which it was possible to recognize the pieces of degenerating larvæ, by the evident coelenterate characteristics, the sum total of this substance did not seem to be at all diminishing. It is impossible to assign any satisfactory explanation to the phenomena, but it is not unlikely that the condition of the water in this particular aquarium-jar was peculiar, owing, perhaps, to evaporation which increased the density, or to the introduction, inadvertently, of some chemical.

While it is not possible to explain the phenomena here described, or to determine their significance, the facts are stated in the hope that they may call forth other facts which may have a bearing on the same subject. It would be most interesting to discover whether such degenerative conditions occur in any other coelenterates; whether they are brought about by any specific external circumstances; and whether creatures which have assumed this condition are capable of resuming their normal form.

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